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ABSTRACT

This curriculum provides a behaviorally written guide that offers a possible list of objectives to assist in establishing or revising an electrical/electronics curriculum. Teachers may choose specific objectives to suit age group and educational level or expertise. Introductory material describes the scope and sequence of an Industrial Arts Program, gives specific guidelines for Industrial Arts, and lists general goals of Industrial Arts. The guide is divided into 26 basic subject areas. Unit topics are provided under each subject area; a general objective and specific objectives are provided for each unit. Areas include theory of matter; direct current circuits; magnetism; electromagnetism; inductance; transformers; capacitance; LCR circuits; electron tube; semi-conductors; trouble shooting; electrical production and transmission; residential wiring; AC circuit mathematics; general motor theory; phasers and phase relationships; power supplies; amplifiers; electronic instruments; electical and electronic assembly methods; electrical, electronic, and electrical wiring symbols; integrated circuits; radio receiver; transmitter circuits; and computer theory. (YLB)

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INDUSTRIAL ARTS CURRICULUM GUIDE

FOR

ELECTRICITY/ELECTRONICS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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Foreword

The purpose of this curriculum is to provide a behaviorally written guide that is meant to offer a possible list of objectives to assist in establishing or revising an electrical/electronics curriculum. In no way is this guide meant to be a mandated curriculum.

It is the position of this committee that the field of electronics is in a constant state of rapid change, and offers a tremendous variety of subject areas, such that it would be a virtually insurmountable task to author a complete comprehensive guide to all areas both present and future.

With this salient point in mind we have created a list of behavioral objectives, in each of what we consider the basic areas of electricity/electronics. These objectives are written such as to allow the instructor to pick and choose specific objectives to suit both age group and educational level or expertise.

Introduction

Industrial Arts learning experiences are sequential, beginning in the lowest grades and continuing through adult and higher education. As an integral part of the total educational program, Industrial Arts is designed to meet student's needs as they relate to a modern technological society. Through manipulative and research experiences, with a variety of tools, machines, processes and products of industry, students develop an awareness of how industry and its many components function.

A comprehensive Industrial Arts program will provide for a sequence of courses in industrial areas. These include, but are not limited to:

drafting
electricity/electronics
general lab
graphic arts
industrial ceramics
metal technology
plastic technology
power technology
wood technology

The objectives of Industrial Arts are:

. . . . . To develop an insight and understanding of industry, its place in our society, and the free enterprise system.

. . . . . To develop problem solving skills related to the materials, tools, processes and products of industry.

. . . . . To provide for a degree of skill development through a series of

sequential courses in common industrial areas with vocational emphasis at the advanced levels.

. . . . . To develop knowledge of the tools, machines, materials and processes of industry through their practical and safe use.

. . . . . To develop an appreciation of good design and craftsmanship.

. . . . . To develop an understanding of industrial and technological career opportunities and their requirements.

. . . . . To develop those traits which will help students obtain and maintain employment.

. . . . . To develop consumerism regarding the goods and services of industry.

. . . . . To discover avocational and recreational interests.

. . . . . To understand the affects of industry and civilization upon the environment.

The following sequential phases represent a range of Industrial Arts activities from kindergarten through adulthood. Reference is made to grade level to assist LEA's in planning. It is understood that a wide variety of grade organizations are employed based upon local situations.

I. Self-Awareness (grades K-6)

Industrial Arts at this level is designed to familiarize students with the many kinds of work people do and the tools and materials they use. It is at the elementary level that Industrial Arts activities are used to

enhance basic skills and understandings in all curricular areas by providing relative hands-on experiences.

II. Industrial Arts Exploration (grades 7 & 8)

Industrial Arts at the middle school/jr. high school level is designed to foster the development of a strong foundation in the concepts, skills, knowledges and attitudes regarding not only the technical but also the related and social aspects of general education.

Industrial Arts experiences at this level are exploratory in nature. The program provides students with the opportunity to develop a better understanding of their interests, abilities and aspirations. Consumer knowledge as it relates to industrial products and processes is an inherent part of these activities. A broad exploratory Industrial Arts program at the middle school/jr. high school level allows individual student's interests to become more discernible for concentration at the senior high level.

III. Industrial Arts Occupational Orientation (grades 9 & 10)

Industrial Arts at this level emphasizes occupational orientation. It is here that the transition from middle school/jr. high school exploratory experiences to specialization at the upper levels is made. Students may explore in greater depth a wider variety of areas, evaluate their performance, aptitudes and interests and begin to formulate career plans.

IV. Industrial Arts Specialization (grades 11 & 12)

At this level students are provided the opportunity to specialize in one or more occupational areas and to develop pre-vocational skills. Training at this level should prepare students to maximize their career options after high school.

This level should also assist individuals in making informed and meaningful occupational choices and/or prepare them for entry into advanced trade and industrial or technical education programs.

V. Adult, Continuing and Higher Education Industrial Arts programs are designed for adults and out of school youth. These programs are avocational, pre-vocational or vocational in nature depending upon the needs of the individual and the demands of society.

Specific Guidelines for Industrial Arts

Grade Level

7 - 12 and adult

Selection of Students

Open to all students who can profit from instruction, and work safely in a Lab/Shop situation.

Length of Program

Level One (Exploratory) grades seven (7) and eight (8) - Lab/Shop classes meet a minimum of 60 hours per year. Lab/Shop periods must be of at least 40 continuous minutes and should not exceed 60 minutes.

Level Two (Occupational Orientation) grades nine (9) through twelve (12), or grades ten (10) through twelve (12) - students electing Level Two Industrial Arts courses must have the opportunity to participate in a minimum of 225 minutes of Lab/Shop activities per week, per semester. Daily Lab/Shop periods must be of at least 45 continuous minutes and should not exceed 60 minutes.

Level Three & Four (Specialization and Pre-Vocational) grades eleven (11) and twelve (12). Students that elect Level III & IV Industrial Arts courses must have a minimum of 450 minutes per week, per year of Lab/Shop activities. Daily Lab/Shop periods must be of at least 90 continuous minutes.

The definition of a year is a minimum of 180-day school days.

A semester is 90 continuous school days.

Pre-Requisites

Successful completion of Level Two course prior to participating in Level Three. Successful completion of Level Three course prior to Level Four.

Enrollments

Based on Lab/Shop size and facilities, 16 students per class maximum in Lab/Shop areas and 20 students per class in drafting. The recommended and minimum square footages are as follows:

	Recommended		Minimum	
Jr. & Sr. High School	s.f./pupil station	Net total s.f.area	s.f./pupil station	Net total s.f.area
Drafting (including storage)	48 sf	1200 sf	40 sf	1000 sf
I.A. Jr. H.S. Level One (including storage)	100 sf	2500 sf	82 sf	2050 sf
I.A.Sr. H.S. Levels Two, Three & Four (including storage)	144 sf	3600 sf	120 sf	3000 sf

A classroom should be made available for related study, adjacent to the Shop/Lab areas. All facilities must comply with OSHA regulations.

Teachers Schedule

Industrial Arts contact hours for a full-time instructor should comprise

70% to 80% of their school week, and 20% to 30% of their time in Industrial Arts related non-teaching duties, such as maintenance and preparation of I.A. materials.

Equipment

All equipment must be in safe operating condition and conform to all federal, state, and local standards. Equipment must be:

A. Applicable to the level being taught, i.e., size, capacity, quantity, and necessity.

B. Enhance the program level and be similar to that found in industry.

C. Take into consideration: occupational education, consumer competency, leisure time activity, and environmental awareness.

Evaluation

Continuous evaluation by students, teachers, school, vocational, advisory committee, and state. Evaluation results must become an integral part of program development and improvement.

School Credit

Equal to other academic credit granted for similar periods of time and activities.

Youth Organizations

It is recommended that the American Industrial Arts Student Association (AIASA) be an integral part of the curriculum.

-x-

Teacher Certification

Instructors shall meet the minimum standards for Industrial Arts teachers provisional certification as outlined in the "Rules and Regulations Concerning State Teacher Certification" section 10-146-21 and section 10-146-22.

Standard certification requires three (3) years of teaching under a provisional certificate, the last two (2) years consecutive and a master's degree or thirty (30) semester hours, consisting of a planned program at an approved institution of higher learning and an individual program, mutually determined and approved by teacher and supervising agent.

Teachers of Industrial Arts to be funded through the Vocational Education Acts must comply with section 10-146-22 above, have one (1) year of appropriate occupational experience and complete Principles of Vocational Education, a three (3) semester hour Vocational-Technical Education course.

Sex Stereotyping

Existing activities and future plans must show evidence of actions directed toward the elimination of sex stereotyping, including continual effort to attract females to elective industrial arts courses traditionally chosen by males. Industrial Arts courses which are required for any students at a particular level must be required of all students, male and female.

Goals of Contemporary Industrial Arts Education

In the process of determining objectives for Industrial Arts, an exhaustive research of our own Connecticut State educational data, as well as the leading literature, authors and documents, centralizes upon the following.[1]

"Many of the objectives and the goals of Industrial Arts in the past were either repetitious or geared to the popular theories of the psychology of the times. As a result, the program and its justifications were open to criticism when such theories were either generally abandoned or simply discarded in favor of newer or more exciting theories of the learning process.

(1) What is Industrial Arts attempting to accomplish in the school system, and (2) How does it propose to accomplish whatever it is that it is purporting to do?..."

An analysis of Industrial Arts' goals developed in the past reveals that many of the goals were untenable; others, controversial. To provide a sound program of Industrial Arts, clear, realistic goals are essential. These are being advocated and are believed to be unique to Industrial Arts:

(A) Develop an Insight and Understanding of Industry and Its Place In Our Culture.

(B) Discover and Develop Talent, Aptitudes, Interests and Potentialities of Individuals for the Technical Pursuits and the Applied Sciences.

(C) Develop an Understanding of Industrial Processes and the Practical

Application of Scientific Principles.

(D) Develop Basic Skills in the Proper Use of Common Industrial Tools, Machines and Processes.

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[1] Lindbeck, J. R., "Practical Guide to Industrial Arts Education," The Center For Applied Research In Education, Inc., NY, 1972, pp. 37-39.

I. Theory of Matter

A. Properties of Matter

1. General Objective

To explore the physical make-up of matter as it relates to basic electrical theory.

2. Specific Objectives

At the conclusion of this unit the student will be able to:

a. Define mass, weight, volume, and inertia.

b. Describe the composition of elements, mixtures, and compounds according to the electron theory.

c. Differentiate between solids, liquids, and gases.

d. Define energy.

e. List at least four forms of energy.

f. State the laws of conservation of energy and matter.

B. Atomic Structure

1. General Objective

To investigate the structure of the Bohr atom.

2. Specific Objectives

At the conclusion of this unit the student will be able to:

a. List the atomic subparticals

b. Diagram the Bohr atom showing the relative position, charge, number, and movement of electrons, protons, and neutrons.

c. State the law of charges.

d. Describe the location movement of electrons at various

energy levels within the atom.

e. Determine atomic weight and number.

C. Electrical Properties

1. General Objective

To examine the electrical characteristics of materials as they apply to basic electrical and electronic components.

2. Specific Objectives

At the conclusion of this unit, given electrostatic demonstration materials, an ohmeter, and assorted conductors and non-conductors, the student will be able to:

a. Explain electrical potential in terms of electron loss or gain.

b. Describe current flow in solids, liquids, and gases.

c. Explain conductivity in conductors, non-conductors, and semi-conductors.

d. List at least three common conductors used in electrical distribution.

e. List at least five common non-conductors used in electrical and electronic circuitry.

f. List at least two semi-conductors commonly used in electronic circuitry.

g. Demonstrate the laws of attraction and repulsion.

h. Use an ohmeter to identify conductors and non-conductors.

II. Direct Current Circuits

A. Circuit Characteristics

1. General Objective

To examine the electrical characteristics of a simple DC circuit.

2. Specific Objectives

At the conclusion of this unit, given paper and pencil, power supply, resistors and other necessary materials, the student will be able to:

a. Define voltage, current, resistance, and power.

b. List the unit of measure and letter symbols for voltage, current resistance and power.

c. State the relationship of voltage and resistance to current.

d. Explain the conditions that must be met to form a simple DC circuit.

e. Draw a diagram for a simple circuit using proper schematic symbols.

f. Construct a simple circuit to meet given specifications.

g. Use a VOM to measure voltage, current, and resistance in a simple DC circuit.

h. Differentiate between open and short circuits.

B. Ohm's Law

1. General Objective

To investigate the mathematical relationship between voltage, current, and resistance in simple DC circuits.

2. Specific Objectives

At the conclusion of this unit, given pencil and paper, circuit characteristics, and other necessary materials, the student will be able to:

a. State Ohm's Law three ways.

b. Use Ohm's Law to solve for unknowns with two knowns given.

c. Use Ohm's Law to solve word problems with two circuit characteristics described.

d. Design a simple circuit to meet given specifications of voltage current, and resistance with any two facts given.

C. Electrical Power

1. General Objective

To analyze power dissipation in a simple DC circuit.

2. Specific Objectives

At the conclusion of this unit, given paper and pencil, known circuit characteristics, and other necessary materials, the student will be able to:

a. State the power formula three ways.

b. Define electrical power.

c. Give at least three examples of electrical energy power dissipation.

d. State the relationship of electrical power to voltage and current.

e. Use the power formula to solve for unknowns with two knowns given.

f. Solve word problems with two circuit characteristics described.

g. Combine Ohm's Law and the power formula to form PIRE wheel.

h. Use the PIRE wheel to solve compound problems of Ohm's Law and power requirements of simple DC circuits.

i. Read a Watt hour meter.

j. Solve for electrical power usage cost using typical appliances and up to date utility rates.

D. Series DC Circuits

1. General Objective

To analyze DC circuits in terms of voltage drops, current flow, resistance and power dissipation.

2. Specific Objectives

At the conclusion of this unit, given paper and pencil, necessary components, circuit diagrams or specifications, power supplies, meters and other necessary equipment, the student will be able to:

a. Define a series circuit.

b. Explain the effect of a series circuit on voltage.

c. State Kirchoff's law.

d. Compute voltage drops in a series circuit give necessary circuit specifications.

e. Explain current in series circuits.

f. Calculate for total resistance in a series circuit.

g. Use the proper meter to correctly measure voltage drops, current, and resistance in a series circuit.

h. Design a voltage divider to meet given specifications.

i. Design a series circuit current limiting and/or voltage dropping resistor to meet circuit needs.

j. Draw a diagram for a series circuit using proper schematic symbols.

k. List at least three advantages of series circuits.

l. List at least two disadvantages of series circuits.

m. Name four electrical or electronic devices that are almost always wired in series with other circuit components.

E. Parallel Circuits

1. General Objective

To analyze a DC parallel circuit in terms of voltage, current, resistance, and power.

2. Specific Objectives

At the conclusion of this unit, given paper and pencil, necessary components, circuit diagrams or specifications, power supply, meters and other necessary materials, the student will be able to:

a. State the electrical characteristics of parallel circuits in terms of voltage, current, resistance, and power.

b. Calculate total resistance in parallel circuits.

c. Compute current flow in parallel branch circuits.

d. Use the proper meter and correctly measure voltage, current, and resistance in parallel circuits.

e. Design and construct a parallel circuit to meet given circuit specifications.

f. Draw a diagram for a parallel circuit using proper schematic symbols.

g. List several advantages of parallel circuits.

h. List several disadvantages of parallel circuits.

i. Name at least two electrical or electronic devices that are almost always wired in parallel with other circuit components.

F. Combination DC Circuits

1. General Objective

To analyze combination DC circuits in terms of voltage drops, current, resistance, and power dissipation.

2. Specific Objectives

At the conclusion of this unit, given pencil and paper, necessary components, circuit diagrams or specifications, power supply, meters, and other necessary materials, the student will be able to:

a. Recognize series and parallel combinations in circuit diagrams or in actual diagrams.

b. Solve for total resistance by forming equivalent circuits.

c. Find voltage drops and current flow in combination circuits.

d. Analyze power dissipation in combination circuits.

e. Use the proper meter and correctly measure voltage, current, and resistance throughout a combination circuit.

f. Solve for voltage drops, current flow, and total resistance in bridge circuits.

g. Design and construct combination circuits to meet given circuit requirements.

III. Magnetism

A. Classifications of Magnets

1. General Objective

Student will be able to classify magnets into three distinct groups.

2. Specific Objective

At the completion of this unit, given a pencil and paper, the student will be able to define in his own words a natural magnet, an artificial or permanent magnet, and an electromagnet.

B. Earth Magnetism

1. General Objective

Student will be able to comprehend Earth as a huge magnet and be able to locate the geographic magnetic poles.

2. Specific Objective

At the completion of this unit, given a pencil and paper, the student will be able to sketch the approximate location of the North and South geographic poles with connected lines of force illustrated.

C. Magnetic Poles

1. General Objective

Student will be able to locate and identify the North and South poles of a bar magnet.

2. Specific Objectives

At the completion of this unit, given one bar magnet, course iron filings, two feet of string and a piece of chalk, the student will be able to:

a. Dip one end of the magnet and then the other into the filings and observe how the filings are aligned by the magnetic force.

b. Tie the magnet to the string at midpoint and hang free well away from steel objects, label, and explain the term "northseeking pole".

D. Lines and Fields of Magnetic Force

1. General Objective

Student will understand the concept of and be able to differentiate between flux lines and field of force.

2. Specific Objectives

At the completion of this unit, given one bar magnet, iron filings, and a sheet of paper, the student will be able to:

a. Sprinkle iron filings on a paper covering a bar magnet and observe the path of lines of magnetic force.

b. Construct a lines-of-magnetic-force map.

E. Characteristics of Magnetic Force

1. General Objective

Student will comprehend the law of magnetic poles, the behavior of flux lines, the direction of magnetic force and magnetic force vs. distance.

2. Specific Objectives

At the completion of this unit, given a pair of bar magnets, string, flat eraser, the student will be able to:

a. Demonstrate with the bar magnet and string that like poles repel and unlike poles attract.

b. Demonstrate with the bar magnets, flat eraser, iron filings and paper that flux lines of like poles repel and flux lines of unlike poles attract.

c. Demonstrate with bar magnets the international agreement that magnetic force is said to act in the direction in which it pushes an N-pole which is free to move. Magnetic force acts from the north pole to the south pole.

d. Demonstrate with a bar magnet and nail that the more closely a magnetic object approaches a magnet, the more strongly the magnet's force will act on it.

F. Magnets In Series And In Parallel

1. General Objective

Student will understand that individual magnets can be linked together in various ways to produce a stronger magnetic force.

2. Specific Objectives

At the completion of this unit, given three identical medium length bar magnets, a ring magnet, 8 short bar magnets, a sheet of paper and iron filings, the student will be able to:

a. Demonstrate that when two or more bar magnets of identical size are attached to each other with unlike poles facing, their flux lines increase in length, but the number of lines remains that of a single magnet.

b. Demonstrate that if small bar magnets are arranged in the shape of a ring, their magnetic force will be similar to that of a ring magnet. The student will observe that in a true ring magnet, all flux lines stay inside the metallic ring.

c. Demonstrate that if three magnets having 10,000 flux lines each are laminated together, the resulting parallel magnet has 30,000 flux lines. Its magnetic energy will be three times that of a single magnet.

G. Non-Magnetic and Magnetic Materials

1. General Objective

Student will know that the magnetic materials are iron, nickel, cobalt and their various alloys. Likewise, the student will know that substances that do not contain one of these three metals are the non-magnetic materials.

2. Specific Objectives

At the completion of this unit, given a piece of aluminum, a horseshoe magnet, sheet of paper, iron filings, flat eraser and piece of iron, the student will be able to:

a. Demonstrate that flux lines are not affected by non-magnetic materials.

b. Demonstrate that flux lines are in fact rerouted by magnetic materials.

H. Induced Magnetism

1. General Objective

Student will understand how it is possible to bring about, or induce, temporary magnetism in a piece of soft iron.

2. Specific Objectives

At the completion of this unit, given a strong permanent magnet, a piece of soft iron and a small nail, the student will be able to:

a. Demonstrate that a piece of soft iron is brought close to a nail, it will not attract the nail.

b. Demonstrate that if the experiment is repeated and a permanent magnet is held above the iron, the iron will attract the nail as long as the permanent magnet is nearby.

I. Magnetic Flux Measurement

1. General Objective

Student will understand that the standard unit of measurement of the number of magnetic lines of force or magnetic flux, is the Weber, abbreviated Wb.

2. Specific Objectives

At the completion of this unit, given a paper and pencil, the student will be able to:

a. State that one Weber is equal to 10 to the eighth power, or 100 million lines of force.

b. State that the symbol used to represent magnetic flux is the Greek letter phi: ϕ

J. Magnetic Field Strength Measurement

1. General Objective

Student will understand that because the amount of magnetic lines of force may vary with different sizes and shapes of magnets, it is necessary to know both the number of lines of force and the size of the area through which they pass.

2. Specific Objectives

At the completion of this unit, given a pencil and paper, the student will be able to:

a. State that the measurement of the magnetic field strength is known as the Flux Density.

b. State that the standard unit of measurement is the Tesla, and is identified by the capital letter B.

c. State that a Tesla is equal to a Weber per square meter; that is, 10^8 magnetic lines of force passing through an area one meter by one meter. This relationship between the Weber and the Tesla can be put in the form of a single formula:

$$\text{Tesla } B = \frac{\phi}{M^2}$$

d. State that where phi ϕ equals number of lines of force in Webers, and M^2 equals the cross-sectional area of the magnetic path in square meters.

IV. Electromagnetism

A. Oersted's Experiment

1. General Objective

Student will understand and perform Hans Christian Oersted's electromagnetism experiment.

2. Specific Objective

At the completion of this unit, given a number 6 dry cell, 36 inches of 20 gauge copper wire and a magnetic compass, the student will be able to demonstrate that free electrons moving through a conductor generate an invisible magnetic force.

B. Electromagnetic Force

1. General Objective

Student will understand that the magnetic force of the electron current acts along circular flux lines at right angles to the conductor, and be able to employ the left-hand rule.

2. Specific Objectives

At the completion of this unit, given a number 6 dry cell, 36 inches of 20 gauge copper wire, iron filings, several cardboard squares and five small magnetic compasses, the student will be able to:

a. Demonstrate lines of force around a current-carrying conductor.

b. Demonstrate that the electromagnetic force acts along the entire conductor.

c. Demonstrate the relationship between the direction of electron flow and the direction of the resulting electromagnetic force.

d. Demonstrate the left-hand rule for single conductors which states that: If the thumb of the left hand points along the conductor in the direction of the electron flow, the curled fingers point in the direction of the electromagnetic force.

C. Electromagnetic Forces Between Parallel Conductors

1. General Objective

Student will understand that when two conductors, each carrying an electron current, come close to one another, their electromagnetic forces interact.

2. Specific Objectives

At the completion of this unit, given two No. 6 dry cells, 36 inches of copper wire, iron filings, and a cardboard square, the student will be able to:

a. Demonstrate how mutual attraction occurs when both electron currents flow in the same direction through the conductors.

b. Demonstrate how mutual repulsion results when the electron currents flow in opposite directions through the parallel conductors.

D. The Electromagnet

1. General Objective

The student will understand that when a current-carrying conductor is wound into the shape of a coil, the flux lines of the individual turns merge to form an electromagnetic field similar to that of a bar magnet.

2. Specific Objectives

At the completion of this unit, given copper wire to coil, iron filings, power supply, magnetic compass and a cardboard square, the student will be able to:

a. Demonstrate the iron filings pattern of a current-carrying coil.

b. Demonstrate that the electromagnetic field changes its intensity whenever the current increases or decreases.

c. Demonstrate that if the direction of the electron flow through the coil is reversed, the magnetic poles reverse also.

d. Demonstrate the left-hand rule for coils which states that: If a current-carrying coil is held in the left hand with the fingers pointing in the direction of the electron flow through the windings, the thumb will point toward the N-pole of the coil's magnetic field.

E. Strength of an Electromagnet

1. General Objective

The student will understand that the strength of the electromagnet depends on three factors.

2. Specific Objectives

At the completion of this unit, given paper and pencil, the student will be able to:

a. State that the greater the number of turns in a coil, the more individual conductors will add their magnetic force to the total field, and the stronger will be the resulting electromagnetic force.

b. State that the greater the electron current flowing through a coil, the stronger will be the coil's field of force.

c. State that the higher the permeability rating of the metal used for the coil's core, the stronger will be the magnetic field created by the electron current.

d. Define magnetomotive force and ampere-turn.

e. Calculate the magnetomotive force, in ampere-turns, of a given coil carrying a given current.

F. The Solenoid

1. General Objective

Student will understand that the solenoid is the basic moving mechanism used in electromechanical devices.

2. Specific Objectives

At the completion of this unit, given paper and pencil, the student will be able to:

a. Sketch a simple solenoid.

b. Describe the operation of the solenoid.

G. The Relay

1. General Objective

The student will understand that a relay is an electromagnetic switch which is operated by remote control.

2. Specific Objectives

At the completion of this unit, given a paper and pencil, the student will be able to:

a. Sketch a basic relay.

b. Describe the operation of the relay.

V. Inductance and it's Laws, Properties, Characteristics, and Applications

A. Laws and Properties of Inductance

1. General Objective

To understand the use and theory of operation and properties of inductors.

2. Specific Objectives

At the conclusion of this unit, given various and assorted cores, coils of wire and the appropriate test equipment, ammeter, voltmeter and compass, P & P, a student will be able to:

a. Define:

1. Inductor

2. Inductance

3. Counter EMF

4. HENRY

b. Explain the theory of inductance.

c. Describe the physical aspects of inductors.

d. Solve series and parallel compilations of inductors.

e. Demonstrate inductive reactance.

f. Calculate inductance and resistance in combined circuits.

B. Inductors

1. General Objective

To understand the characteristics and applications of inductors.

2. Specific Objectives

At the conclusion of this unit, given various and assorted cores, coils of wire, and the appropriate test equipment, ammeter, voltmeter and compass, P & P, a student will be able to:

a. Define and demonstrate:

   1. Effective resistance

   2. Ohmic resistance

   3. Skin effect

   4. Eddy current loss

   5. Dielectric loss

   6. Corona loss

   7. Radiation loss

b. Derive figure of merit.

c. Define and demonstrate mutual inductance.

d. Explain degree of coupling.

e. Demonstrate coil arrangements.

f. Construct low frequency inductance coils as used in:

   1. Power supplies

   2. A-F transformers

   3. Output transformers

g. Demonstrate the use of high frequency inductance coils as applied to:

   1. R-F chokes

   2. R-F transformers

   3. Variable inductors

VI. Transformers

Transformer Operation and Construction

1. General Objective

   To understand the theory of operation and application of inductance to transformer operation.

2. Specific Objectives

   At the conclusion of this unit, given assorted transformers, coils, a compass, P & P, voltmeter, ammeter, and test leads, a student will be able to:

   a. Define magnetic induction.

   b. Explain transformer action.

   c. Calculate power in transformer circuits.

   d. Explain and demonstrate transformer construction noting:

      1. Shell core transformer

      2. Closed core transformer

      3. Auto transformer

   e. Calculate transformer losses.

   f. Explain consideration in transformer construction namely:

      1. Rating

      2. Shielding

VII. Capacitance

1. General Objective

To investigate the general theory, operation, and use of the capacitors in electronic circuits.

2. Specific Objectives

When the student completes this unit, he will be able to:

a. Explain what a capacitor is and how it stores electrical energy.

b. Demonstrate his skill in applying proper safety precautions when working with capacitors.

c. Explain how capacitors are used in circuits in terms of how it regulates the flow of current.

d. Explain how a capacitor is constructed.

e. Understand the electrical principles of capacitors in terms of electrostatic fields.

f. Evaluate the charge and discharge rate of capacitors.

g. Construct basic capacitor circuits for timing, wave shaping, blocking and coupling electronic signals.

h. Test to determine the quality of a capacitor for leakage, shorts, and intermittent conditions.

i. Define the factors that determine the capacitance of a capacitor.

j. Explain the phase relationship between current and voltage in a capacitive circuit.

k. Determine the value of capacitance resistance and explain how this limits the flow of current.

l. Determine the value of current through application of Ohm's Law for capacitive circuits.

m. Determine the total capacitance and capacitance reactance for capacitors in series and parallel combinations.

n. Analyze the effect of capacitance on DC and AC signals.

VIII. LCR Circuits

A. Series LCR Circuits

1. General Objective

   To understand the use of the resistor, inductor, and capacitor with respect to their relationship to each other in series with an alternating voltage.

2. Specific Objectives

   At the conclusion of this unit, given various inductors, resistors, capacitors, voltmeter, ammeter, P & P, a student will be able to:

   a. Explain voltage and current relationships graphically.

   b. Demonstrate the general series circuit equations.

   c. Measure and graph the components of series resonant circuits.

B. Parallel LCR Circuits

1. General Objective

   To understand the use of the resistor, inductor, and capacitor with respect to their relationship to each other in a Parallel Resonant Circuit.

2. Specific Objectives

   At the conclusion of this unit, given the necessary equipment and materials, a student will be able to:

   a. Note and graph the characteristics of an inductance-resistance circuit.

   b. Note and graph the characteristics of a capacitance circuit.

   c. Note and graph the characteristics of an inductance-capacitance circuit.

   d. Record the effect of resistance in an LCR circuit.

e. Measure, find, and calculate the impedance of a parallel resonant circuit.

f. Measure the currents in a parallel resonant circuit.

g. Define and plot curves demonstrating selectivity and band width in a resonant circuit.

C. Applications of LCR Circuits

1. General Objective

To understand the specific purposes and applications of LCR circuits.

2. Specific Objectives

At the conclusion of this unit, given the necessary equipment, capacitors, coils, and P & P, a student will be able to:

a. Demonstrate the components of selectivity, sensitivity and tunability in a resonant circuit.

b. Show a series resonant circuit and its action in selecting a signal at its resonant frequency.

c. Show a parallel resonant circuit and its action in selecting a signal at its resonant frequency.

d. Demonstrate the additive effect of the secondary winding of a transformer in an LCR circuit.

e. Demonstrate the filter characteristics of LCR circuits to separate currents and voltages namely:

1. Low-Pass filters

2. High Pass filters

3. Band Pass filters

4. Band Reject filters

f. Illustrate graphically and identify different types of multi-section filters.

g. Demonstrate the use of filter circuits in the various stages of electrical and electronic circuits.

IX. Electron Tubes

1. General Objective

To investigate the origin, theory and application of this unique device in the development of electronic technology. Various tubes will be studied with respect to historic development, construction, theory of function, and the tubes' role at the center of the electronic circuit.

2. Specific Objectives

At the end of this unit, the student will be able to:

a. Explain how electrons move in a vacuum between two plates having a difference in potential.

b. Explain how a cathode emits electrons and how the plate attracts them.

c. Recognize the active elements symbols used by manufacturers for tubes.

d. Plot Ep and Ip curves for diode tubes and determine its plate resistance at various voltage points.

e. Explain how the operating characteristics of a diode tube can be used for detection, clipping, clamping, and gating.

f. Analyze how the value of plate current is controlled by a control grid in a triode tube and the effects that changes in grid and plate voltage have on plate current.

g. Plot a graph of triode plate current versus grid voltage to determine the value of plate resistance as grid voltage changes.

h. Use a receiving tube manual to locate the characteristics, ratings, parameters, and uses of selected vacuum tubes.

i. Explain how grid bias is developed and how its value controls and sets the operating point of a vacuum tube.

j. Explain the effect of interelectrode capacitance and how these effects are decreased in multigrid tubes.

k. Interpretation of tube data from a family of characteristic curves for triodes and pentodes.

l. Define what a vacuum tube is and explain the differences between diode, triode, tetrode, and pentode tubes.

m. Demonstrate his skill in applying proper safety precautions when working with vacuum tubes.

X. Semi-Conductors

1. General Objective

To investigate the general theory and application of these unique devices and their adaptation to replace certain electron tubes.

2. Specific Objectives

At the conclusion of this unit, the student will be able to:

a. Compare the advantages and disadvantages of transistors to vacuum tubes.

b. Explain the atomic formation of germanium and how it permits the flow of electrons and holes.

c. Explain the difference between N-type and P-type material and how they contribute to the flow of minority and majority current carriers.

d. Explain PN Junction diode action when operated in forward or reverse reverse bias.

e. Identify the symbols for NPN and PNP transistors.

f. Explain how a transistor is biased and how voltage and power gain are determined.

g. Determine transistor operating characteristics, ratings and operating values from manufacturer's specifications.

h. Explain the precautions necessary when working with solid state devices.

i. Explain the technique used in removing, installing and testing semi-conductors.

j. Explain the checks typical diode and transistor can make and how to interpret the results.

k. Design, construct, and experiment with semi-conductor devices (transistor circuits).

l. Give a detailed description of how transistors amplify and how its amplification compares with a vacuum tube amplifier.

m. Explain what a transistor is in terms of variable resistance and how it is used in simple amplifier and control circuits.

XI. Trouble Shooting

A. Trouble Shooting Plan

1. General Objective

Produce a plan of operation for trouble shooting common electrical devices.

2. Specific Objectives

Given a specific electrical device or circuit as a trouble shooting problem, the student will be able to:

a. Employ a schematic diagram for the analysis of a problem.

b. Illustrate the relationship of the major subsystems.

c. Apply given procedures recommended by a manufacturer.

d. Memorize some of the common symptoms associated with specific electronic devices.

B. Performing the Trouble Shooting Procedures

1. General Objective

Perform a trouble shooting procedure in an organized, accurate and safe manner.

2. Specific Objectives

Having been given a specific electrical problem that requires a trouble shooting procedure, the student will be able to:

a. Use the more common test instruments for measuring purposes.

b. Follow the safety procedures used in trouble shooting.

c. Memorize the more common schematic symbols.

d. Conclude which direction a procedure should follow.

e. Check for the calibration of his instruments.

f. Perform the trial and error method of trouble shooting using parts that are known to be good.

C. Deriving a Solution

1. General Objective

After planning a procedure and following that procedure, the student will be able to find the solution to a specific problem.

2. Specific Objectives

After completing a plan and procedure, the student will be able to:

a. Formulate a hypothesis based upon the results of testing procedures.

b. Isolate problems down to component level.

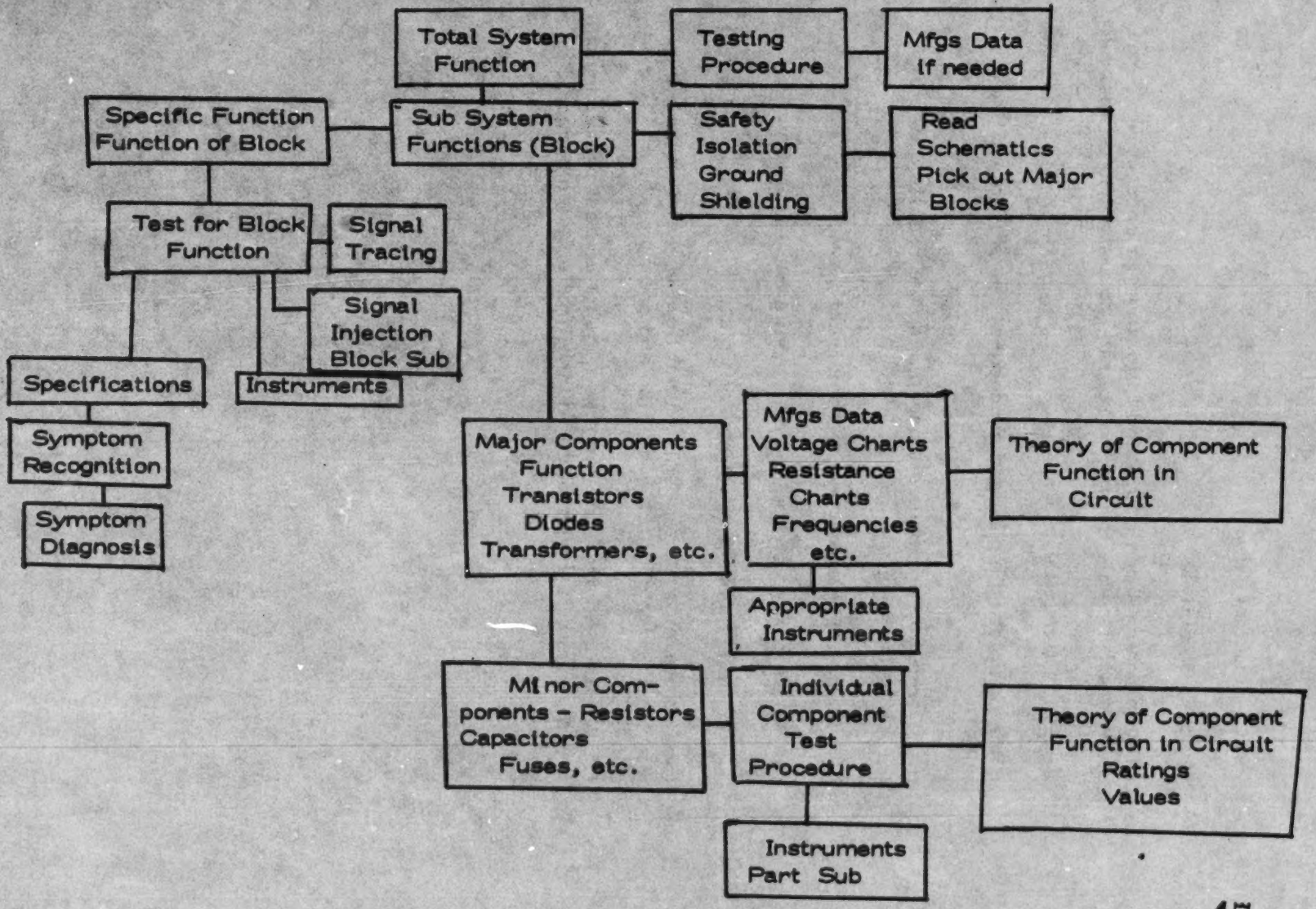
c. Write a simple supply order from a catalog.

d. State component specification units.

e. Communicate effectively with fellow workers or suppliers in order to obtain information and components.

f. Write a report explaining the symptoms, test procedures, diagnosis of the problem and the final solution derived.

TROUBLE SHOOTING BLOCK DIAGRAM


Total System Function
Testing Procedure
Mfgs Data if needed
Specific Function Function of Block
Sub System Functions (Block)
Safety Isolation Ground Shielding
Read Schematics Pick out Major Blocks
Test for Block Function
Signal Tracing
Signal Injection Block Sub
Specifications
Instruments
Symptom Recognition
Symptom Diagnosis
Major Components Function Transistors Diodes Transformers, etc.
Mfgs Data Voltage Charts Resistance Charts Frequencies etc.
Theory of Component Function in Circuit
Appropriate Instruments
Minor Components - Resistors Capacitors Fuses, etc.
Individual Component Test Procedure
Theory of Component Function in Circuit Ratings Values
Instruments Part Sub

46

47

XII. Electrical Production

A. Common Methods of Producing Electricity

1. General Objective

   Students will recognize the basic methods of production.

2. Specific Objectives

   At the conclusion of this unit, given paper, pencils, galvanometer, magnets, rods, silk and a zinc carbon battery kit, the student will be able to:

   a. List the ways of producing electricity.

   b. Describe the processes of each.

   c. Construct a device which will demonstrate one method of production.

   d. Differentiate between methods of electrical production.

   e. Indicate practical applications of each.

   f. Translate in his own words how AC and DC are different.

B. Batteries

1. The cell.

2. Cell applications.

3. Secondary cell.

4. Considerations.

5. Review questions.

C. Alternating-Current Fundamentals

1. Alternator theory.

2. Variation of alternating emf.

3. Frequency spectrum.

4. Hertz.

5. AC values.

6. Measuring alternating current.

7. Review questions.

XIII. Electrical Transmission

Types of Conductors

1. General Objective

   To investigate the different types of electrical conductors used in the transmission of electricity.

2. Specific Objectives

   At the conclusion of this unit, given paper and pencil, students will be able to:

   a. List the more common types of electrical transmission devices.

   b. Distinguish between the different methods of transmission.

   c. Describe how electricity flows in each method.

   d. Decide which method is the most economical and practical for various conditions.

XIV. Residential Wiring

A. Wiring Tools, Terminology and Codes

1. General Objective

Students will recognize the tools, terminology and building codes needed to perform electrical construction wiring.

2. Specific Objectives

At the conclusion of this lesson, students will be asked to identify the following:

a. Differentiate the basic house wiring hand tools.

b. Choose the correct graphic symbol which matches the various electrical components.

c. Explain the terms used in construction wiring.

d. Describe in their own words the electrical code and inspection procedures.

B. Conductors and Units of Measurement

1. General Objective

Students will evaluate the types of wires and cables, how they can be fastened to each as well as to components, and what electrical measurements are used in residential wiring.

2. Special Objectives

Given pencil, paper, wire samples, connectors and formulas, students will be asked to:

a. Distinguish between different types of insulation and conductors.

b. Select the proper wire size according to its current carrying capacity.

c. Decide what type of cable to use for each wiring situation.

d. Demonstrate how to cut and strip wire and cable.

e. Connect wire to each other and to terminals.

f. Define the meaning of voltage, amperage, watts, and ohms, as used in the construction wiring field.

g. Describe how a watthour meter is used.

C. Service, Wiring Components, and Specialty Components

1. General Objective

To comprehend the parts of a home electrical service as well as what wiring components are used in construction wiring.

2. Specific Objectives

Students will, at the end of this unit, be able to:

a. List the various parts needed to complete a home electrical service.

b. Indicate the proper heights the entrance cable must be above driveways, street, walkways, and roofs.

c. Recite the types of grounding used in electrical systems.

d. Compare fuses with circuit breakers as disconnecting means.

e. Write the basic types of boxes needed in house wiring.

f. Distinguish the various kinds of wiring components needed to do house wiring, such as, outlets, switches and light fixtures.

g. Appraise where specialty components could be used.

h. Substitute various types of outlet covers in place of components.

D. Basic Circuits - Raceways

1. General Objective

Students will demonstrate the more common types of circuits used as well as how these conductors are run.

2. Specific Objectives

Given boxes, wire, cable, conduit, wiremold, benders, and components, students will do the following:

a. Design the following circuits:

1. Single-pole switch circuit

2. Three-way switch circuit

3. Split-outlet circuit

4. Four-way switch circuit

b. Prepare a circuit which uses any two electrical raceways.

c. Demonstrate the ability to use the bender.

E. Low and High Voltage Circuit

1. General Objective

Students will understand that low voltage (10 v.) and high voltage (220 v.) circuits are needed in residential wiring.

2. Specific Objectives

Using transformers, wire, bells, push buttons, three conductor cable and special outlets, pencil, paper, etc., student will be able to:

a. Reconstruct a door bell circuit.

b. Plan an oil burner control hook-up.

c. Describe the wiring of an intercom circuit.

d. Explain how the following are connected:

1. Hot water heater (electric)

2. Electric heater

3. Air conditioner

4. Ranges

5. Dryers

F. Installation on Finish Walls

1. General Objective

To apply basic house wiring skills to finish constructed homes.

2. Specific Objectives

At the conclusion of this unit, given cable, boxes, paper, pencil, madison clips, and snake, the students will be able to:

a. Demonstrate how to wire in an outlet in finished walls.

b. Describe basic home construction.

G. State Licensing

1. General Objective

To investigate how a student can be licensed in the state.

2. Specific Objectives

At the conclusion of this lesson, given the proper information, students will be able to:

a. Evaluate for which license they qualify.

b. Meet certain licensing procedures.

c. Know what to study for becoming licensed.

XV. AC Circuit Mathematics

Trigonometry and it's Relationship to Electronics

1. General Objective

   To understand alternating current theory and circuits as based upon the knowledge of trigonometry as it applies to the solution of triangle.

2. Special Objectives

   At the conclusion of this unit, a student will be able to solve problems relating to the analysis of AC circuits involving right triangles in one form or another and given P & P will:

   a. Note the meaning and measurement of angles.

   b. Plot the generation of angles.

   c. Check and verify angular measurement.

   d. Identify similar triangles.

   e. Identify and define right triangles.

   f. Summarize factual information about triangles.

   g. Prove the relationship that exists involving trigonometric ratios.

   h. Solve right triangles given adequate information.

   i. Verify the importance of the Sine Function as the most important curve or graph encountered in AC circuits.

   j. Graph the amplitude factor of a Sine Curve.

   k. Graph the frequency factor of a Sine Curve.

   l. Graph the period function of a Sine Curve.

   m. Graph the phase function of a Sine Curve.

   n. Solve practical mathematical problems using the 6 trigonometric functions and co-functions.

   o. Accurately check and verify the use of trigonometric relationship tables.

XVI. General Motor Theory

A. Magnetic Motor Action to Create Torque

1. General Objective

To investigate the theories of magnetic attraction and repulsion as they relate to the creation of torque in an electric motor.

2. Specific Objectives

At the conclusion of this unit, given a pencil and paper, 2 bar magnets, a jar of iron filings and other necessary materials as needed, the student will be able to:

a. State in his own words the law of magnetic repulsion and attraction.

b. Show the existance of magnetic field lines about the magnet.

c. Demonstrate the repulsion of like magnetic poles.

d. Demonstrate the rotational forces exerted by like and unlike magnetic fields.

e. Define in his own words the term torque.

f. Devise and experiment to construct a magnetomotive prime mover.

g. Design and construct a magnetic device which operates on the principle of magnetic repulsion or attraction.

h. Define the terms reluctance and permeability.

i. Classify materials as magnetic or nonmagnetic.

j. State Weber's (Ewing's) theory of magnetism.

k. State the electron spin theory of magnetism.

l. Illustrate the electron spin theory using the bohr model of an atom

m. Classify magnetic materials as permanent or temporary magnets based on reluctance and permeability.

B. Electromagnets for Field and Rotor Components

1. General Objective

To investigate the properties of an electromagnet and the means by which they might be adopted to use in an electric motor.

2. Specific Objectives

At the conclusion of this unit, given a paper and pencil, a spool of #22 magnet wire, paper clips, nails, a piece of ferrite, a power source, and miscellaneous materials as needed, the student will be able to:

a. Illustrate the magnetic field around a coil of wire.

b. Describe in his own words the relationship between electric current and magnetism.

c. Use the left hand generator rule to identify the direction of induced current flow in a conductor.

d. Use the left hand rule to identify the north pole of an electromagnet.

e. Construct a simple electromagnet.

f. Construct a simple universal motor.

g. Design and construct an electromagnet of a given strength for operation at a particular voltage and current.

h. Design, construct, and test a practical device using the electromagnet as the actuating device.

i. Devise test procedures using laboratory instruments to evaluate the performance of an electromagnetic device.

j. Graph and evaluate a series of laboratory tests relating current, voltage, turns of wire, wire size, and magnetic field strength.

k. Define the terms gauss, maxwell, tesla, weber, and flux in the proper M.K.S., C.G.S., S.I. units.

l. Identify the Greek symbols for gauss, maxwell, tesla, and weber.

m. Describe in his own words the relationship between flux density and the number of turns of wire in an electromagnet.

n. Demonstrate that adding a ferrite core to a coil of wire increases it's field strength.

o. Describe in his own words the theory of operation of a simple D.C. or universal motor, i.e., paper clip or band metal motor.

C. D.C. Motors

1. General Objective

To acquaint the student with the various types of commercially available D.C. motors, their theories of operation, their performance curves, their advantages and disadvantages repair techniques and their applications.

2. Specific Objectives

At the conclusion of this unit, given a sample of each type of D.C. motor, a motor test panel, visual aids, a pencil and paper, magnet wire, pole pieces, test equipment, and/or suitable substitutions for any of the above, the student will be able to:

a. Identify the four types of D.C. motors (permanent magnet, series wound, shunt wound, and compound wound).

b. List at least 2 possible applications for each of the four types of D.C. motors.

c. Evaluate a given application and choose a proper motor based on acquired information about each type of motor.

d. Label the main parts of a D.C. motor.

e. Explain the operation of each of the 6 parts of any D.C. motor.

f. Test a D.C. motor for shorts, grounds, and proper operation.

g. Use a megger to determine grounds.

h. Use a pony brake to test shaft horsepower.

i. Properly connect the motor test panel to test the operations of each of the four types of D.C. motors.

j. Describe in his own words the construction of a permanent magnet motor.

k. Describe in his own words the construction of a series wound motor.

l. Describe in his own words the construction of a compound wound D.C. motor.

m. Describe in his own words the construction of a shunt wound motor.

n. Properly connect to the line, for normal operation, each of the four types of D.C. motors.

o. Analyze the torque vs. volt-amp curve for proper motor sizing and selection.

p. Repair insulation damage in a D.C. motor.

q. Inspect D.C. motors for visible defects.

r. Install new brushes in a D.C. motor.

s. Measure and check brushes for proper tension.

t. Remove the pole pieces of a D. C. motor.

u. Properly connect and disconnect the internal connections of each of the four types of D.C. motors.

v. Identify commutation problems based on brush arcing.

D. AC Motors

1. General Objective

To investigate the operation and application of the various types of AC motors, including construction theories of operation, troubleshooting and repair.

2. Specific Objectives

At the conclusion of this unit, given suitable instruction, pencil and paper, test equipment, a motor test panel and miscellaneous materials as needed, the student will:

a. Differentiate between single phase, and polyphase AC motors.

b. Identify the six main parts of a single phase AC motor.

c. Describe the construction and operation of each of the following motors:

1. Split phase

2. Capacitor start

3. Permanent split capacitor

4. Shaded pole

5. Wound rotor

a. Repulsion

b. Repulsion start induction run

c. Repulsion induction

6. Two value capacitor

7. Synchronus motors

a. Shaded pole

b. Hystersis

c. Reluctance

d. Permanent magnet

8. Poly phase

a. Wound rotor

b. Squirrel cage

c. Synchronus

9. Universal motors.

d. Test a single phase motor for shorts, grounds, and general operation.

e. Remove, inspect, and replace bearings on each of the types of AC motors.

f. Properly lubricate the bearings of an AC motor.

g. Describe the function of the centrifugal switch in a split phase motor.

h. Distinguish between the start and run windings of a split phase motor.

i. Identify the symptoms caused by a bad capacitor in a capacitor start single phase motor.

j. Identify electrolytic and oil type capacitors.

k. Properly reverse the rotation of a split phase motor.

l. Properly connect a two voltage AC motor for a given line voltage.

m. Describe in his own words the process utilized to determine the T leads 1-9 in a multi-voltage polyphase motor.

n. List three possible applications for a synchronus motor.

o. Test a synchronus motor for proper line connection.

p. Identify the shading coil in a shaded pole motor.

q. Describe in writing how torque is produced in the shaded pole motor.

r. Reverse the rotation of shaded pole motor.

s. Replace the centrifugal switch in a split phase motor.

t. Describe the theoretical operation of the squirrel cage rotor according to the laws of induction and magnetism.

u. Discuss the operation of the universal motor.

v. List four possible causes of universal motor failure.

w. Use a growler to test a wound armature for shorts.

x. Use an internal growler to test a stator for shorts.

y. Demonstrate three safe procedures for installing new ball or roller bearings on a motor shaft.

z. Differentiate between the following bearings:

1. Ball

    a. Shielded one side

    b. Shielded two sides

    c. Sealed

2. Roller

3. Babbitt

4. Oilite

5. Nylon

aa. Describe the effect of AC industion motors on line power factor.

bb. Calculate the speed of standard AC motors.

cc. Discuss in writing the consequences of slip on motor temperature and current characteristics.

dd. List the items stamped on a motor's nameplate.

ee. Discuss orally the significance of frame size according to NEMA.

ff. List the name from which the acronym N.E.M.A. is derived.

gg. Name three types of varnish used to insulate the wire used to wind motors.

hh. Use glyptol to repair damaged insulation in an AC motor.

E. AC & DC Generators

1. General Objective

To compare and contrast DC generators with DC motors, identify the various types of DC generators and their operating characteristics and troubleshoot, identify and repair common maladies in them.

2. Specific Objectives

At the completion of this unit, given a pencil and paper, a dynamometer, a DC generator, test equipment and tools as needed, the student will:

a. Describe in his own words the difference between a DC motor and a DC generator.

b. Define the term prime mover.

c. Identify in writing the seven basic parts of a DC generator.

d. Explain the phenomenon of residual magnetism.

e. Remove, repair, and replace field coils on the pole pieces.

f. Properly adjust the brush tension on a DC generator.

g. Explain in his own words the function of the commutator.

h. Use a growler to test a generator armature for shorts.

i. Resurface a generator commutator, properly undercut the mica and seat new brushes on a DC generator armature.

j. Draw an illustration of the current flow induced in a single coil DC generator armature.

k. List the precautions to be taken when paralleling generators for simultaneous operation.

l. Properly connect a DC generator to a load.

m. Calculate the expected output voltage and current for a given generator under given conditions.

n. Explain in his own words the effects of eddy currents and hysteresis on generator output.

o. Properly adjust brush rigging for operation in the neutral plane.

p. Describe the proper procedure for putting a generator on, or removing a generator from, the line in accordance with good safety procedures.

q. Identify 6 common causes of generator failure.

r. Use a dynamometer to determine generator operating characteristics.

s. List the principle types of DC generator winding connections, i.e., series aiding, series opposing, compound, etc.

F. AC Generators

1. General Objective

To identify the various types of AC generators, noting their differences and similarities with other rotational machinery, and exploring their construction, common maladies and repair.

2. Specific Objectives

At the conclusion of this unit, given proper test equipment and materials, a pencil and paper, and other miscellaneous materials as needed, the student will:

a. Name the two basic categories of AC generators.

b. Identify an AC generator as revolving field or revolving armature.

c. Describe in his own words the difference between real power and apparent power in rating AC generators.

d. Properly identify the various parts of an AC generator.

e. Discuss single phase, two phase, and three phase operation according to the text.

f. Draw the proper schematics for the wye type connection and for the delta type connection.

g. Describe in his own words the effects of power factor on AC generator operation.

h. Discuss in writing the effects of generator R.P.M. on line frequency.

i. Describe in his own words the effect of armature resistance on armature output.

j. Properly inspect armature slip rings for excess.

k. Calculate the percent of regulation of an AC generator.

l. Properly connect an AC generator to the line for parallel operation.

m. List the proper maintenance for AC generator systems.

G. AC & DC Motor/Generator Controls

1. General Objective

To introduce the student to the area of motor and generator control systems and to give him some insights and experiences as to their operation, maintenance, and repair.

2. Specific Objectives

Given a specific control system and its application, simple hand tools, a V.O.M., and amprobe, a pencil and paper, and other miscellaneous equipment as needed, the student will:

a. Identify the specific systems operation and application.

b. Determine if the control system is proper for the given application.

c. Draw a schematic of the system.

d. Properly identify the schematic symbols for:

1. Normally closed contacts

2. Normally open contacts

3. Fuses

4. Circuit breakers

5. Magnetic relays

6. Bus bars

7. Emergency stop switches

8. Remote devices

e. Identify across the line starters.

f. Identify magnetic controllers.

g. Describe the operation of SCR controlled devices.

h. Successfully troubleshoot and repair the system discussed during the course of instruction.

i. Explain the role of thermal protectors in motor control systems, according to NEMA or other standards.

j. Label all parts of each of the systems discussed by the instructor.

k. Perform routine maintenance on each of the identified systems.

XVII. Phasors and Phase Relationships

1. General Objective

   To understand and investigate graphic methods of expressing both magnitude and directional characteristics of voltages and currents.

2. Specific Objectives

   At the conclusion of this unit, given a pencil, paper and the necessary math tables, a student will be able to:

   a. Show examples of phasors.

   b. Plot the addition of phasors as scalar quantities.

   c. Recognize phasor components.

   d. Solve phasor addition of rectangular components.

   e. Plot phasor representation of Sine Curves.

   f. Demonstrate an understanding of frequency, cycles and poles.

   g. Use equations of voltages and currents.

   h. Interpret phase relations and phase angles.

XVIII. Power Supplies

A. Introduction to Power Supplies

1. General Objective

   To understand the need and construction of power supplies.

2. Specific Objectives

   At the conclusion of this unit, given rectifiers, chokes, electrolytic capacitors, resistors, transformers, voltmeter, and ammeter, a student will be able to:

   a. Know the use of a transformer in a power supply.

   b. Understand rectifier operation.

      1. Half wave

      2. Full wave

   c. Understand peak inverse voltage.

   d. Construct filter circuits

      1. Capacitance filter

      2. Inductance filter

   e. Demonstrate filter combinations.

B. Rectifiers

1. General Objective

   To understand the use of non-rotating devices and to produce direct direct current from alternating current.

2. Specific Objectives

   At the conclusion of this unit, given various types of vacuum and solid state rectifiers, a student will be able to:

   a. Know the construction of electron tube and dry metal rectifiers.

1. Mercury vapor

2. Selenium rectifier

b. Illustrate the characteristics of silicon rectifiers.

c. Demonstrate tunnel rectifiers.

d. Demonstrate the use of silicon controlled rectifiers - SCR.

e. Demonstrate uses of triacs.

f. Determine the need for heat sinks.

C. Voltage Regulators & Dividers

1. General Objective

To understand methods for regulating voltage and current flow from power supplies.

2. Specific Objectives

At the conclusion of this unit, a student given various voltage sources, resistors, and regulating devices will be able to:

a. Define voltage divider noting:

1. Divider load

2. Bleeder resistor

3. Voltage divider resistor

b. Recognize regulator circuits.

c. Understand voltage regulator tubes.

d. Demonstrate semi-conductor regulators.

1. Shunt regulated

2. Series regulated

D. Voltage Multipliers

1. General Objective

To understand various transformerless methods of increasing voltage.

2. Specific Objective

At the conclusion of this unit, given assorted rectifiers and sources of AC current, a student will be able to:

a. Construct a half wave voltage doubler.

b. Construct a full wave voltage doubler.

c. Construct a half wave cascade voltage doubler.

d. Demonstrate voltage triplers.

e. Understand bridge circuits.

f. Construct an AC - DC bridge power supply.

XIX. Amplifiers

A. Amplifiers in General

1. General Objective

To understand the application and general operating principal of transistor and electron tube amplifiers.

2. Specific Objectives

At the conclusion of this unit, given various transistors, tubes, resistors, and capacitors, a student will be able to:

a. Define amplifier.

b. Understand amplifier classifications with respect to:

1. Frequency

2. Voltage and power

3. Operating level

c. Construct a basic electron to be an amplifier.

d. Explain cathode bias.

e. Discuss operating levels.

f. Demonstrate the basic transistor amplifier.

B. R-C Coupled Amplifiers

1. General Objective

To understand the theory of operation and applications of two, three or more amplifier staged cascaded together.

2. Specific Objectives

At the conclusion of this unit, given various transistors, tubes, resistors, capacitors and power supplies, a student will be able to:

a. Construct a triode R-C coupled amplifier.

b. Construct a two-stage R-C Coupled Electron Tube Amplifier.

c. Calculate component values.

d. Determine the effect of component failures.

e. Design a two-stage R-C Coupled Transistor Amplifier.

XX. Electronic Instruments

A. Voltmeter, Ammeter, and Ohmmeter

1. General Objective

Present procedures in the proper use of the voltmeter, ammeter, and ohmmeter.

2. Specific Objectives

Given an electrical circuit consisting of resisters, wiring, a power source, and meters, the student will:

a. Measure voltage and record voltage readings after properly placing probes at each circuit component.

b. Insert the ammeter into the circuit to measure current flowing from the power source.

c. Follow proper procedures to measure the resistance of the resistors while using the ohmmeter, and record scale readings.

B. Oscilloscope

1. General Objective

Develop a working knowledge of the uses and set up of the oscilloscope.

2. Specific Objectives

Given an oscilloscope, an AC signal, a DC source, and a simple audio amplifier, the student will:

a. Show proficiency in preparing the oscilloscope for operation by using the scope controls to produce a trace suitable to accept an input signal.

b. Measure AC and DC voltages and draw the results.

c. Trace an audio signal injected into an audio amplifier and determine gain and phase of each stage.

d. Determine and record the frequency of several AC signals taken from a signal generator after calibrating the trace on the oscilloscope.

e. Connect a dual trace oscilloscope to compare digital pulses.

C. Safety

1. General Objective

Provide safety instruction in use of electronic instruments.

2. Specific Objectives

At the conclusion of this unit, the student will:

a. Follow all safety rules given in the hook up of electronic instruments.

b. Use an isolation transformer whenever an AC device is being tested.

c. Follow the "one hand" rule while working on high voltage devices.

D. Signal Generators

1. General Objective

Introduce the student to various signal generators including application and operating procedures of each.

2. Specific Objectives

At the conclusion of this unit, given a specific signal injection assignment, the student will:

a. Connect an audio sine/square wave generator to an audio amplifier.

b. Inject an AM wave form from a R.F. generator into a transistor radio.

c. Introduce an FM signal into an FM radio using a sweep generator.

d. Use a TV signal generator to produce a video signal and R.F. signal and inject them into the proper stages of a television set.

e. Align tuned circuits of a television using a sweep/marker generator.

f. Adjust color television convergence using the color bar/ cross hatch generator.

g. Use a pulse generator to trigger a count in a digital circuit.

h. Introduce a CB signal into a citizen band radio for trouble shooting purposes.

E. Signal Tracer

1. General Objective

Show the operation and applications of signal tracers in trouble shooting of electronic units.

2. Specific Objectives

Given an audio signal generator, audio amplifier, schematic diagram, and audio signal tracer, the student will:

a. Trace the audio from input to output, noting amplification of the signal in each stage.

b. Locate a defect in an audio amplifier by determining stage in which the signal is lost.

F. Frequency Meter

1. General Objective

Explain the operation and application of digital frequency meters.

2. Specific Objective

Given a digital frequency meter and a signal generator, the student will determine the output frequency of the generator after making proper connections from the meter.

G. Tube and Transistor Tester

1. General Objective

Show the procedures for determining the condition of tubes and transistors according to manufacturers' specifications through the use of testers.

2. Specific Objectives

Given a vacuum tube and semi-conductor tester, the student will:

a. Locate proper specification for the tube on the tester set up sheet and test for gas, shorts, and gain.

b. Use the transistor checker to determine beta and leakage, and compare the results to manufacturers specs.

c. Determine a family of characteristic curves for a transister by using a "transistor curve tracer" and oscilloscope.

d. Check and record the firing voltage and condition of a silicon controlled rectifier by using the SCR tester.

H. Digital Logic Probe

1. General Objective

Show the use of a logic probe to determine the high/low state of a digital circuit.

2. Specific Objective

Given a logic probe and digital circuit, the student will determine the state of each terminal of a digital circuit.

I. Capacitance/Inductance Tester

1. General Objective

Teach the use of the tester to determine the value and condition of capacitors and inductors.

2. Specific Objectives

Given a capacitor and inductor, the student will use the tester to:

a. Measure and record the capacitive value of the capacitor and its dielectric resistance.

b. Determine the value of inductance using the inductance bridge.

XXI. Electrical and Electronic Assembly Methods

A. Point-to-Point Wiring

1. General Objective

   Investigate and demonstrate the following electronic component assembly and electrical wiring methods: a) soldering method, b) wire wrapping method, c) mechanical fastening method.

   Emphasis should be placed on proper soldering techniques.

2. Specific Objectives

   At the conclusion of this unit, given various components, a chassis, assorted wires, a set of shop tools, wire wrapping tool, wire wrapping board, soldering iron, solder, mounting strips and assorted hardware, the student will be able to:

   a. Successfully assemble and wire a given circuit using a soldering iron.

   b. Successfully perform a wire wrapping operation.

   c. Properly thin a wire, solder a wire, and a component to a lug.

   d. List the advantages and disadvantages of these two types of circuit assemblies.

3. Specific Objective

   At the conclusion of this unit, given assorted wire sizes, assorted solderless terminals and a crimping tool, the student will be able to perform various mechanical fastening operations.

B. Printed Circuit Wiring

1. General Objective

   Demonstrate the two methods of making a printed circuit (P.C.) board. Beginning with a schematic diagram to the artwork for a single-sided copper board; to include proper masking, developing, etching of the board, cleaning, drilling and soldering. Mention should be made of the current capacity of the various landlines and pads.

2. Specific Objectives

At the conclusion of this unit, given a single-sided copper clad board, resist ink various components and other necessary parts and equipment, the student will be able to:

a. Design a single-sided P.C. board layout from a schematic.

b. Etch and clean the P.C. board.

c. Properly mount and solder all components.

d. Properly cut and drill the P.C. board.

e. Solder all components onto the P.C. board.

3. Specific Objective

At the conclusion of this unit, given an x-acto knife, various size resist tape, donut pads, a piece of clear mylar sheet, a piece of sensitized single-sided copper clad board and any other necessary materials, the student will be able to:

a. Design and layout a positive master artwork on the mylar from a given schematic.

b. Expose and develop the sensitized board with the positive master.

c. Etch and clean the P.C. board.

d. Drill, properly mount, and solder all components.

C. Breadboarding

1. General Objective

Investigate breadboarding as a first step to wiring and testing of any simple or complex electronic project. Discuss and demonstrate the various ways of making a breadboard.

2. Specific Objectives

At the conclusion of this unit, given a commercially available lab set (to include a commercial breadboard and assorted mounted components), the student will be able to:

a. Put together a simple circuit.

b. Successfully test the circuit and obtain results.

c. List all items required.

3. Specific Objective

At the conclusion of this unit, given a vector board, watching solder type push-in terminals and any other necessary equipment, the student will be able to:

a. Identify a vector board and its solder type push-in terminal.

b. Successfully push in a solder type push-in terminal.

c. Successfully mount components onto the vector board terminals and wire all components.

d. Properly solder all points.

D. Mechanical and Electrical Hardwares

1. General Objective

Demonstrate the use of mechanical and electrical hardware as it applies to the mounting of printed circuits onto a chassis, the fabrication of a chassis and enclosures for electronic projects.

2. Specific Objectives

At the conclusion of this unit, given a completed printed circuit or vector board, assorted machine bolts and nuts, assorted sheet metal screws, grommets, strain relief bushings and any other necessary item, the student will be able to:

a. Successfully mount a printed circuit or vector board out of a chassis or within an enclosure.

b. Select the proper fastening method.

c. Apply a grommet on a predrilled hole.

d. Successfully install a strain relief bushing.

XXII. Electrical, Electronic and Electrical Wiring Symbols

A. Electrical and Electronic Symbols

1. General Objective

   Illustrate the use, the meaning and the application of electrical and electronic symbols. (See Figure)

2. Specific Objectives

   At the conclusion of this unit, given an electrical schematic, the student will be able to:

   a. Trace signal flow in the circuit.

   b. Identify all symbols.

B. Electrical Wiring Symbols

1. General Objective

   Illustrate the use, the meaning and application of electrical wiring symbols. (See Figure)

2. Specific Objectives

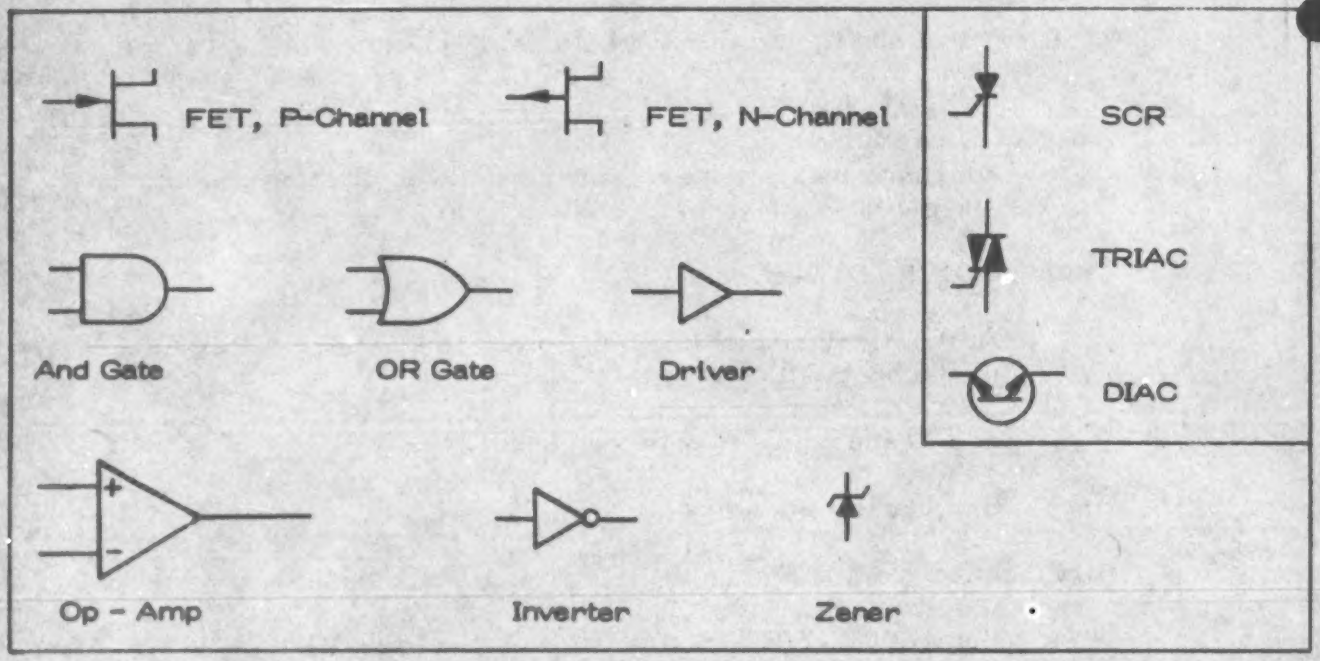
   At the conclusion of this unit, given a house wiring diagram, the student will be able to identify:

   a. The lighting circuit in any room.

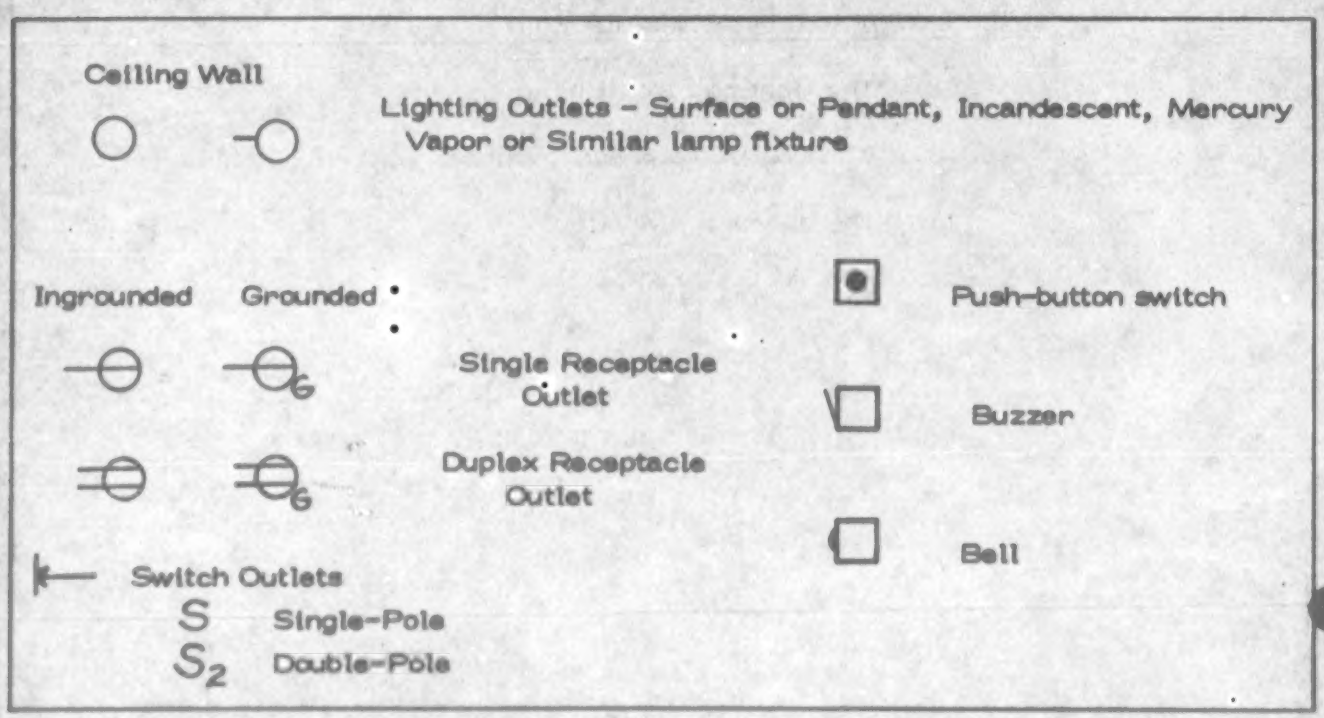
   b. All grounded and non-grounded wall receptacles.

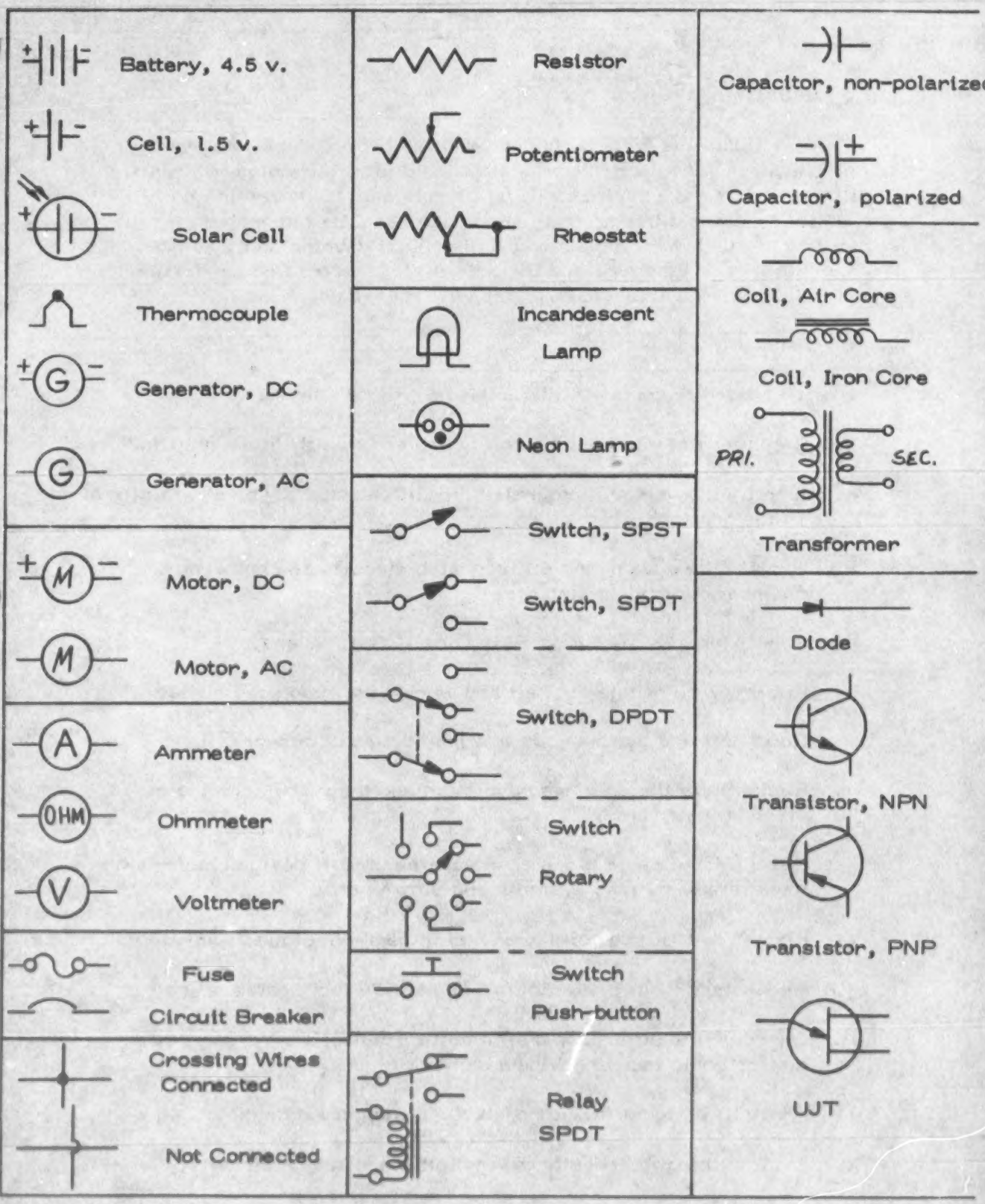
   c. The doorbell circuitry.

Electronic Symbols



Electrical Wiring Symbols




Battery, 4.5 v.
Cell, 1.5 v.
Solar Cell
Thermocouple
Generator, DC
Generator, AC
Motor, DC
Motor, AC
Ammeter
Ohmmeter
Voltmeter
Fuse
Circuit Breaker
Crossing Wires Connected
Not Connected
Resistor
Potentiometer
Rheostat
Incandescent Lamp
Neon Lamp
Switch, SPST
Switch, SPDT
Switch, DPDT
Switch Rotary
Switch Push-button
Relay SPDT
Capacitor, non-polarized
Capacitor, polarized
Coil, Air Core
Coil, Iron Core
PRI.
SEC.
Transformer
Diode
Transistor, NPN
Transistor, PNP
UJT

XXIII. Integrated Circuits

1. General Objective

To investigate the origin, theory and application of the integrated circuit in the development of analog and digital technology. Various active and passive devices will be investigated to determine how digital systems differ from linear systems. The integrated circuit will be studied with respect to its historical development, construction, theory of function, and the role it plays in the 3rd generation of major electronic devices. (tabs-Xistors-IC's)

2. Specific Objectives

When a student completes this unit, he will be able to:

a. Explain what integrated circuits are and how they are manufactured.

b. Identify the various integrated circuit package styles and families of designations.

c. Explain the advantages of integrated circuits as compared to discrete component circuits.

d. Know what V.L.S.I., M.S.I., and L.S.I. means.

e. Know how to handle, install and work with integrated circuits.

f. Construct and test various integrated circuit networks.

g. Explain now the chip has revolutionized the manufacturing of electronic products.

h. Describe the basic types of integrated circuit designs along with their pin numbering systems and dimensions.

i. Know how logic circuits are used to perform digital operations.

j. Understand what truth tables are and how logic gates operate.

k. Describe the differences/similarities between the 3 generations of electronic technology development.

l. Analyze a signal flow through basic integrated circuits.

m. Explain the difference between digital and linear circuits.

n. Determine faulty integrated circuits through knowledge of circuit arrangements and signal testing.

o. Understand the safety precautions which must be exercised when working with integrated circuits.

p. Ident fy the symbols used for terminal connections on the various integrated circuit packages.

q. Construct integrated circuit arrangements for timing, amplifying, waveshaping, blocking, and coupling electronic signals.

r. Understand the differences in the basic integrated circuit logic gates.

XXIV. Radio Receiver

A. History of Communication

1. General Objective

To investigate the different types of communication, when they were introduced and by whom.

2. Specific Objectives

At the conclusion of this lesson, given paper and pencil, the students will be able to:

a. State the various means of communication before the radio.

b. Identify inventors of communication.

c. List the dates of each invention.

B. Simple Radio

1. General Objective

To investigate what parts make up the basic radio.

2. Specific Objectives

The students with paper, pencil, schematic drawings, and parts of a radio will:

a. State in their own words the four basic parts of a radio.

b. Identify by schematic drawings each part of the radio.

c. Describe the function of each part.

C. Amlitude Modulation & Radio Amplification Stages

1. General Objective

To investigate the wave action of transmission and amplification.

2. Specific Objectives

Given paper, pencil, radio components, the students will be able to:

a. Illustrate a block diagram of the tuned radio frequency.

b. Describe how waves of transmission are separated into the receiver.

c. Outline the superheterodyne receiver.

D. The Tuning Circuit

1. General Objective

To understand the ability of a radio receiver to select frequencies.

2. Specific Objectives

Given pencil, paper, radio components, the student will be able to:

a. Describe what tank circuit means.

b. Illustrate a tuning selector circuit.

c. Summarize what selectivity means.

E. Detection Characteristics

1. General Objective

To see how the detector removes the RF wave.

2. Specific Objectives

Given pencil and paper, the students will be able to:

a. Draw the wave form as they become demodulated.

b. Describe what a detector accomplishes.

F. Transistor Superheterodyne Receiver

1. General Objective

To investigate the parts needed for a transistor radio.

2. Specific Objectives

Given paper, pencil, block diagram, the students will:

a. Distinguish the various parts in a block diagram.

b. Identify the stages in the diagram.

c. Draw the wave form diagram for each stage.

XXV. Transmitter Circuits

A. Transmitter Circuits

1. General Objective

   To understand the basic theory of operation and circuitry of simple transmitters.

2. Specific Objectives

   At the conclusion of this unit, a student supplied with a typical amateur or CB Transmitter will be able to:

   a. Identify a basic transmitter.

   b. Block diagram a typical transmitter.

   c. Describe the operation of a buffer amplifier.

   d. Classify transmitter amplifiers.

   e. Describe frequency multipliers.

   f. Construct bias circuits.

      1. Fixed bias

      2. Self bias

      3. Cathode bias

   g. Measure transmitter output.

B. Transmitter Tuning

1. General Objective

   To understand the need of a properly tuned transmitter loaded into an efficient antennae.

2. Specific Objectives

   At the conclusion of this unit, a student supplied as in the above section will be able to:

a. Make minor supervised tank circuit adjustments.

b. Correctly tune and couple an antennae.

c. Provide for neutralization and parasitic suppression.

C. Modulation of Transmitters

1. General Objective

To understand how information is applied to a transmitter to produce a useable radio signal.

2. Specific Objectives

At the conclusion of this unit, given the necessary test equipment, a transmitter and an oscilloscope, a student will be able to:

a. Identify modulated wave components.

b. Display amplitude modulation.

c. Display frequency modulation.

d. Identify AM & FM modulation circuits.

e. Recognize input and output circuit modulation.

f. Compare tube and transistor transmitters.

g. Identify discriminator circuits.

XXVI. Computer Theory

Introduction to Computers

1. General Objective

   To introduce and investigate the theory of operation of information storage, retrieval, and analysis.

2. Specific Objectives

   At the conclusion of this unit, given pencil, paper, background information, a "home" type computer, and other necessary materials, the student will be able to:

   a. List the system components of a computer.

   b. Describe the various methods of information storage.

   c. Describe the basic principle of operation.

      1. Retrieval of stored information.

      2. Perform mathematical operations.

      3. Repetition of multiple functions.

   d. Understand stored program concepts.

   e. Understand the various switching functions.

      1. Switching time

      2. Delay time

      3. Storage time

      4. Turn on-off time

      5. Real time concept

   f. Understand gating circuits

      1. OR gate

      2. AND gate

3. NOR gate

4. NAND gate

5. AND OR gate

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